Opportunities for Electronic Commerce in Networking

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ABSTRACT There are numerous opportunities to apply electronic commerce technologies to networking. These include the assembly, pricing, and payments for complementary infrastructure resources, and the selection of and payment for value-added collaboration and information access services. EC can support the separate provision and coordination of these elements, or allow them to be bundled by a customer care organization. These opportunities and options are discussed.

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Rudimentary examples of electronic commerce (EC) in networking include the "dial-around" services to make per-call choices of competitive carriers and Web-based clearinghouses for excess capacity.[1] Opportunities for more sophisticated uses of EC — particularly when terminals harbor intelligence and a rich user interface — are discussed in this article.

SOME OPPORTUNITIES

There are many motivations for EC in networking. The consumer faces a choice of providers, and two or more providers may be needed for end-to-end connectivity. Networks will provide flexibility in quality-of-service (QoS) attributes (e.g., rate and delay) and a great diversity in end-user functionality, such as information access (e.g., the Web), EC transactions (e.g., stock purchases), and collaboration (e.g., remote conferencing and collaborative authoring). These may be bundled with infrastructure services (with added revenues for providers) or purchased separately (requiring coordination). Increasingly, terminals will be nomadic (and even mobile) with a location-dependent provider. EC can match consumers with suppliers and providers, compare competitive options, coordinate complementary purchases, and make payments.

SOME TERMINOLOGY

Networking and computing use inconsistent terminology [1–3], so we define industry-neutral terminology. The user is an individual, a group, or an organization that purchases products and services. A taxonomy is shown in Fig. 1. *Infrastructure* benefits a variety of uses, whereas *user functionality* leverages an infrastructure for specialized capabilities directly benefiting users. Either may be purchased as a product (operated by the user for his own benefit) or *service* (operated by a *service provider* for the benefit of many simultaneous users). For example, telephony can be purchased as a product (software application supporting Internet telephony on a user-owned terminal) or a service (from a public telephone network service provider). An important distinction is that a service carries an explicit provider responsibility for quality and availability. The most fundamental infrastructure is *connectivity*, and a specific connectivity is *bearer service*, which includes QoS attributes such as availability, rate, loss, reliability, and delay.

A user may purchase separately and integrate complementary products and services, or may purchase a *bundle* (e.g., a terminal, bearer service, and stock quotes, all from an information provider), requiring behind-the-scenes coordination, and revenue splitting. In a sealed-bid auction, either competitive sellers or potential buyers make bids, which are selected by the other.

EC FOR INFRASTRUCTURE SERVICES

CONSUMER EC

Traditionally, users enter long-term contracts with infrastructure service providers at published prices. Past networks have provided a single service or a small set of service options, but future networks will offer very wide ranges of bit rates (from zero to hundreds, or megabits per second and higher) and QoS options (such as differentiated services in the Internet). EC could provide a means for the user to explore possibilities and signal choices, and pay accordingly. One opportunity is for dynamic pricing of services per session, rather than by long-term subscription.

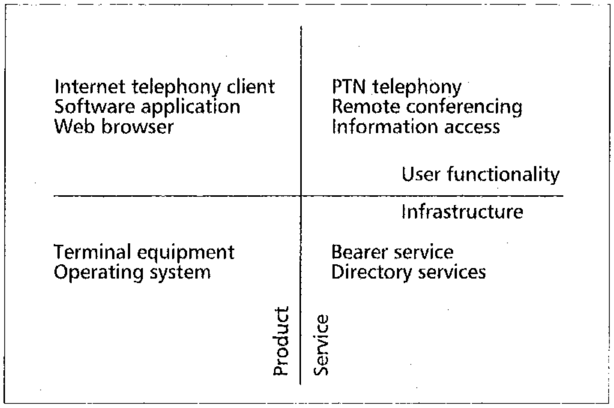
INTERPROVIDER EC

End-to-end bearer service often requires complementary resources from different providers, for example, a wireless access and long-distance carrier, as shown in Fig. 2. Infrastructure providers may want to establish per-session QoS contracts and traffic attributes with users and configure internal network resources accordingly. For example, with future broadband access links, configuration and pricing based on rate attributes may be appropriate. (In the past, this has been approximated by fixed prices based on restricted access speed options.) Wireless access subnetworks with the flexibility required for a variety of user functionality may need configuration and pricing based on bit error rate, delay, and availability objectives.

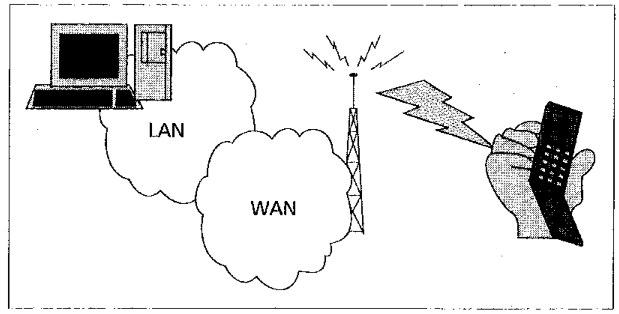
Achieving a specified QoS requires coordination to configure resources, set an aggregate price, and split revenue. Traditionally this has been handled by static interconnect and settlement agreements. With a plethora of service options, such agreements may become too cumbersome. Interprovider EC could substitute dynamic mechanisms for coordination and pricing, and, to keep sellers honest, competitive seller bidding to users.

This might work as illustrated in Fig. 3. The user desig-

[1] *Examples include Arbinet (www.arbinet.com), Band-X (www.band-x.com), and RateXchange (www.ratexchange.com).*



■ **Figure 1.** *A two-dimensional taxonomy of goods and services in networking, with examples.*



■ **Figure 2.** *Complementary networks are required to provision end-to-end infrastructure services.*

nates a *broker* to obtain competitive bids and configure a service option. Upon a request from the broker, sets of providers controlling complementary resources (like subnetworks forming end-to-end connectivity) form a temporary *syndicate* to generate a bid, and provision and charge if the bid is accepted. An *arbiter* designated by each syndicate coordinates individual *resource managers*, gathers price bids from the managers, and aggregates the results as a bid to the broker. For example, the broker may specify end-to-end delay objectives, and the arbiter coordinates complementary subnetworks to partition that delay among subnetworks and gather the resulting prices. The broker, arbiters, and resource managers may be software agents transported to a single host for negotiation in minimum time [4–6]. Competitive bidding is not essential to this model.

Scenarios similar to Fig. 3 are an interesting topic for research. Each syndicate wants to minimize its price bid to maximize the chance of winning. If end-to-end QoS attributes must be disaggregated to individual subnetworks, minimizing price requires an additional negotiation among resource managers; for example, wireless access links and congested subnetworks would be allocated the greatest impairments. Mechanized negotiations of this type have been studied by economists.

Economic Considerations

An alternative to dynamic pricing is extensions to current fixed interconnect and settlement processes. The user may contract with a local provider (which, with nomadicity, may depend on location), who has predefined fixed-price contracts with complementary providers. EC could allow pricing to be dynamic — at the expense of increased (although hopefully modest) transaction costs — and also enable differentiated QoS guarantees with associated pricing. Providers could vary prices at will, based, for example, on requested QoS, current traffic conditions, and indications of user willingness to pay.

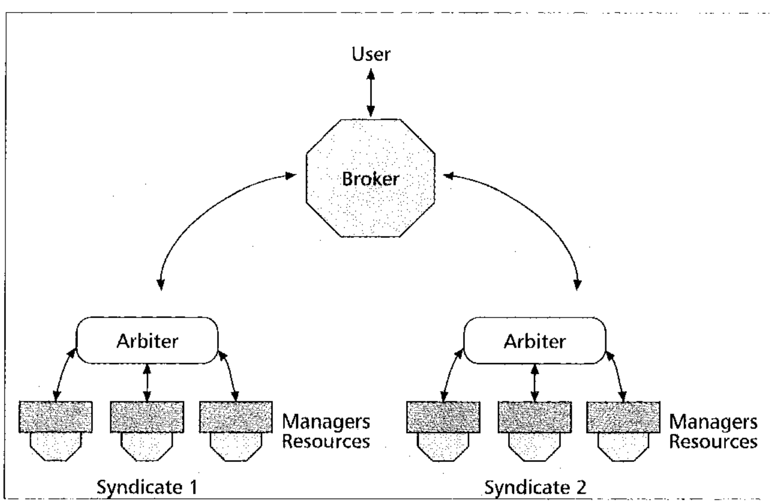
Transaction costs can be reduced by overprovisioning facilities to provide superb QoS to all users (although this is unlikely in wireless access networks). To evaluate these alternatives, transaction costs should be compared to the value added to both users and providers. They are worthwhile if that value is greater, as measured by user willingness to pay and/or economic advantages to the provider. This value proposition is now discussed, first for users and then for providers. The many issues raised here are complex and poorly understood; there is no "right" answer at the present state of knowledge [7].

Value to the User — QoS configuration accommodates differentiation by user functionality and user preference. As an extreme example, telesurgery has more stringent requirements than email. If the network provisions differentiated QoS, associated pricing is inevitable, since otherwise a rational user would always choose the highest QoS option.

During congestion — primarily an issue limited to wireless access subnetworks in the future — resources must be rationed, and pricing is the usual mechanism for matching supply and demand. As a form of congestion control, willingness to pay voluntarily distinguishes compelling needs from those that can be deferred. All other forms of congestion control are involuntary; a user may be unable to obtain desired resources no matter how compelling the need. QoS also shifts risk from the user to the provider, increasing value and willingness to pay.

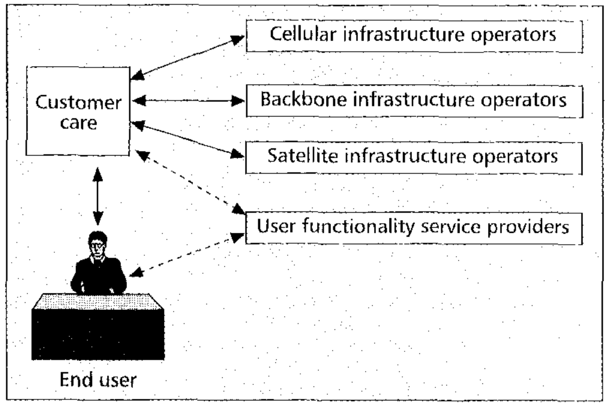
Competitive bidding for services increases competition and reduces price. It also obviates user lock-in to providers due to switching costs (which allows providers to increase prices) [8]. Bidding also allows easier market entry, increasing competition. See the article by Vielmetti in this issue.

Value to Providers — For providers, dynamic optimization of resources based on network conditions and user demand would result in efficient resource allocation, for example, by allocating greater impairments to congested facilities. Dynamic pricing would reserve resources for the users with the highest willingness to pay, increasing rev-



■ **Figure 3.** *An approach to competitive sealed bidding for infrastructure services.*

Examples of customer care functions
- Trusted relationship with the end user: and with infrastructure providers
- One-stop shopping
- Authentication and payment
- Optimized roaming agreements
- Integration of service mechanisms on a single smart card
- Selection and recommendation of user functionality service providers
- Personal customization (language, physical impairment, etc.)
- National customization (regulations)
- Management of bids on behalf of the user
- Management of multiple-purchase transactions
- Conflict prevention and resolution



■ **Figure 4.** *Connectivity is one service among many.*

enue. Facilities would be more fully utilized — for example, by incrementally reducing prices until filled — also increasing revenue. Congestion pricing is a source of revenue for needed facility expansions.

Networks have large economies of scale — high fixed costs of construction and low operational costs — which introduce special challenges. Absent congestion, the *marginal* cost of provisioning a new service request is low. Competition tends to drive prices toward this low marginal cost, resulting in operating losses. There are also social costs: Scale economics create winner-take-all effects, since a dominant provider can undercut the prices of others. Dynamic pricing supported by EC offers some solutions to these dilemmas.

A key to dealing with scale economics is *value pricing* — tying prices to the user value (expressed by willingness to pay) rather than costs [8]. Willingness to pay varies widely, so value pricing requires *differential pricing* — charging different prices to different users. One established technique is *quality differentiation* or *versioning*, in which users self-select from among versions. Those with a high willingness to pay typically choose more expensive, high quality versions. Options and prices can be designed so that users with a high willingness to pay are not tempted by cheaper versions. (These strategies are familiar in the airline industry, which experiences similar economic challenges.) QoS provides a natural dimension for versioning and value pricing strategies. Alternatively, buyer auctions — an extreme form of value pricing — are advantageous to the provider, since users directly signal willingness to pay.

Policy Issues — Versioning can address *universal service* (expanding service to a wide segment of the population) by a market mechanism. With fixed prices, providers tend to ignore users with less willingness to pay in the pursuit of maximum revenues. It is socially desirable for higher-quality versions to be offered without precluding lower-quality options for those able to pay less.

Interprovider QoS provisioning is important to preserve competition in the industry, and may as a result be mandated. To see this, assume there are two service providers. Each user derives greater value when connected to a larger universe of users, including those of the other provider — this is called a *network externality* — so the providers will likely make interconnect arrangements. However, if QoS is more predictable staying within a single provider's facilities, users prefer the network with the larger user base, biasing the market toward a dominant provider.

EC FOR USER FUNCTIONALITY SERVICES

The greatest opportunities for provider profits are in value-added user functionality services.

COLLABORATIVE SERVICES

Collaborative services, such as telephony, remote conferencing, and collaborative authoring [1, 2], benefit most from QoS configuration. It is widely assumed (as described earlier) that users will control bearer service QoS directly. However, a user is interested in perceptual measures directly related to user functionality, such as audio or video quality or interactive responsiveness.

It is natural for user functionality to present perceptual quality options and associated prices (e.g., representative examples of video quality) and relate them to QoS and infrastructure service pricing [9]. It understands the contextual relationship between QoS and perceptual quality (e.g., bit error rate and video quality for a specific coding) and can thus relate user and infrastructure concerns. It then subsumes the role of broker in Fig. 3.

INFORMATION SERVICES

A separate provider will frequently offer information services such as newspapers, financial information, and video on demand. Separate payment may be required for the infrastructure, the information service, and the information content. EC can support the choice of providers and content and payments. This is particularly sensitive to transaction costs— the charge for individual pieces of information is normally small — and thus, an interest in *micropayments*.

Bundling infrastructure and information is common today (e.g., 900 service in the United States), but this is a legacy of the wireline telephone, where a terminal is permanently connected to a local provider with a subscription. A nomadic user may deal with many providers, making a bundle less attractive, and EC can mitigate the resulting inconvenience. This is illustrated by the third-generation mobile system Universal Mobile Telecommunications Service (UMTS) [10, 11]. Tokens obtained from a UMTS infrastructure provider are passed from user to information service provider as proof of credit worthiness. The UMTS provider collects billing information from all information providers, aggregates them, and bills the user.

CUSTOMER CARE

As described, a user may obtain complementary products and services from a variety of sources, burdening him with integration unless there is a third-party *customer care intermediary*. This organization is a single point of contact and responsibility, encompassing both infrastructure and user functionality, as shown in Fig. 4. It could provide secure, evolvable, and anonymous payment mechanisms [13], and subsume the role of the broker in Fig. 3. It also addresses the proliferation of advanced user functionality and providers, much as credit card associations arose to mediate among consumers, banks, and merchants. Finally, it relieves the user of worrying about different underlying network organizations and the hybrid character of services [12].

OTHER ISSUES

EXPLOITING A COMMON EC INFRASTRUCTURE

Historically, infrastructure services have been provided by subscription with direct monthly aggregated billing. UMTS continues this tradition. EC enables other business models such as immediate payment for services. Rather than each provider providing separate user billing, a common shared billing infrastructure, similar to the credit card associations, could be developed. This may be more flexible and cost-effective, and reduce credit risk to providers.

AUTHENTICATION AND PRIVACY

A necessary ingredient of EC, user authentication to prevent fraud, has a major downside for users in the loss of privacy. Authentication allows providers to log user activities, and data warehousing and mining potentially allow tracing and aggregation across a variety of suppliers and providers. Without definitive privacy policies, the development of a dynamic market may be stifled. A customer care organization can preserve user anonymity and enforce privacy policies. See the article by Wing and O'Higgins in this issue.

CONCLUSION

EC can support both infrastructure and user functionality services, bundled or unbundled. These opportunities enable greater choice and competition, hopefully without inconvenience or transaction costs. Research is needed to fully qualify and quantify these opportunities.

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